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Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Why Automobile Oils Must Be Periodically Renewed

Lubrication of Railway Motor Cars

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LUBRICATION

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Why Automobile Oils Must Be Periodically Renewed

"MOTOR oils should be changed after every 500 miles of operation". How familiar is this statement becoming to every one of us who drives an automobile. Yet it may often seem to be at variance with the fact that motor oils, as marketed today by reputable oil refiners, are distinctive for their original purity and durability. Then why are we advised to change our oil?

"If it is good oil", argues the average motorist, "Why am I advised to drain my crankcase, perhaps discard the oil therein when it is not used up, or is apparently good, and refill with new lubricant after every 500 miles my car runs?" The reason is CONTAMINATION.

Contamination, however, is a broad term. Essentially it means the presence of foreign impurities in the lubricant which not only impair lubrication but are actually injurious to the engine. In fact, contaminated lubricants are the cause of the majority of engine troubles usually experienced. Scored or burned out bearings, worn or scored cylinders and piston rings, and loss of compression are all indirectly due to dirty oils. The dirtier they may be the greater the possibility of damage and expense. For this reason motor oils must be changed at regular intervals, before they become so contaminated as to cause trouble. The fact that they are changed or drained from the engine, however, does not mean that their lubricating value is entirely lost, because even extremely contaminated oils can be effectively reclaimed if treated properly. And properly purified motor oils may be quite as suitable from a lubricating point of view as new oils. But as a general rule the average motorist has not the requisite equipment to properly reclaim his oils, and it will be cheaper and safer for him to supply new oil to his engine at each draining. Nor is it advisable for him to purchase reclaimed motor oils from dealers unless the responsibility of the source is above question.

In every automobile, truck or tractor engine there will be a certain opportunity for the entry of foreign impurities of both liquid and solid nature.

Liquid impurities are of two classes, *i.e.*, fuel and water. The former gives rise to dilution; the latter to emulsion.

Solid impurities essentially comprise grit, dirt, metallic particles and carbon, all of which combine to form sludge.

Dilution

Dilution, or the reduction in the viscosity of internal combustion engine oils in the crankcase, is a pertinent topic to every motorist today. The fact that automobile manufacturers recommend lubricants of certain viscosities for summer and winter service, is no protection against dilution. However rigidly the motorist may adhere to these recommendations DILUTION will always occur in his crankcase. This is realized by the automobile manufacturer and the oil marketer when they make their recommendations. For example, the recommendation of a 300 seconds viscosity oil does not indicate that the absolute maintenance of 300 seconds viscosity is necessary. It simply means that in practical running a new oil of 300 seconds viscosity is the best, all factors of operation being considered.

Essentially dilution is due to one of two conditions, *i.e.*:

1. Leakage of a certain amount of unburned fuel past the piston rings during compression.
2. A certain amount of fuel being retained by the film of lubricant on the cylinder walls during admission and compression.

Dilution is generally regarded as being intimately influenced by the engine temperatures. In other words the temperature of the cylinder heads must be sufficiently high to insure complete vaporization and burning of the fuel. Otherwise more or less of the heavy ends or fractions of low volatility will remain unvaporized.

In order to burn gasoline or kerosene effectively in an internal combustion engine, it must be atomized and mixed with a certain amount of air. To attain efficient vaporization this mixture of fuel and air must be heated well above 100° F. in order to prevent the mixture from being excessively wet. The direct result of wet mixtures will be dilution of the lubricating oil in the crankcase. When the engine is operating under moderate temperature conditions, either atmospheric or by virtue of its own generated heat, little or no difficulty will be experienced in vaporizing the average grades of gasoline. Under relatively cold engine conditions, however, the amount of gasoline which will vaporize normally will be decidedly lower.

There are two ways by which this difficulty can be somewhat overcome, *i.e.*, by use of gasolines of relatively higher average volatility, or by "priming" or "choking" of the carburetor. "Priming" is the addition of an extra amount of gasoline to the cylinders through the pet cocks or priming pumps. "Choking" constitutes the manipulation of the carburetor in order to increase the richness of the mixture or obtain approximately the requisite percentage of fuel in the form of gas by reducing the amount of air delivered to the carburetor on starting. Carburetors are normally adjusted when hot in order to obtain good fuel economy, and to decrease dilution; hence a certain amount of control by means of the choke is made necessary in order to meet cold weather conditions, as mentioned above.

Priming and choking, however, while they facilitate starting of a cold engine, are also conducive to increased dilution inasmuch as under such conditions less of the gasoline will vaporize than when operating under normal temperatures. As a result, considerably more of the higher boiling point fractions will remain in liquid state, to leak past the piston rings and either wash the film of lubricating oil from the cylinder walls, or become so incorporated with this film that consequent reduction in its viscosity will result. The ultimate consequence of either of these occurrences will be dilution due to entry of the fuel into the crankcase. Due to the fact that the cylinder walls would always be insufficiently lubricated at such a time after the use of the choke, the engine should be operated at moderate speeds until the film of lubricant is renewed on all surfaces where any washing action has taken place.

It is evident that during cold weather operation with average fuels we will therefore experience more or less dilution, due to the presence of unvaporized fractions of the fuel in the system. The use of more volatile gasolines would, of course, obviate this condition to a certain extent. In general, however, there is little difference in average gasoline volatility, whatever the season. Hence priming and choking are the alternate recourses. The fact must not be overlooked that dilution will occur with any motor fuel even where so-called high

test aviation gasolines are used. The higher the volatility, however, the less will be the necessity for using the choke in cold weather operation.

Both priming and choking must be carefully carried out. Especially in the use of the choke will there be the possibility of considerable dilution occurring. If used excessively for any length of time naturally a comparatively uniform flow of very rich mixture will occur. The correct way is to alternately work the choke slowly back and forth until sufficient explosions have taken place to insure continued operation. It should then be pushed in gradually and the engine idled until sufficiently warmed up. During the process of warming up it is well to adjust the spark and throttle levers as nearly as possible to a point where the engine will run evenly and fire on all cylinders. Where cars are equipped with a primer, in very cold weather the priming charge should be shot into the manifold while turning the engine over with the starter. This will insure getting the charge into the combustion chamber.

The question of using higher volatility grades of gasoline so frequently arises that it is well to discuss this subject briefly. Today gasolines contain considerably more of the lower volatile hydrocarbon fractions than formerly, due primarily to the efforts of production to meet demand. Gasolines produced under modern refinery processes have a higher final boiling point than those which were formerly manufactured. As a result they are heavier in comparison and require higher temperatures for vaporization, notwithstanding the fact that they are capable of developing more power.

Dilution will also vary to a certain extent with the design and mechanical condition of the engine, as well as with the volatility of the fuel. Where an engine is designed especially to burn a certain grade of fuel the possibility of dilution occurring will be decreased. Most engines are so built, and a tractor engine designed to burn kerosene should show no more dilution than an automobile engine designed for gasolines of considerably higher volatility. The increased temperature of operation in event of heavy service will decrease the rate of dilution to a certain extent by virtue of the fact that the so-called heavy ends of the fuel will be more completely vaporized and burned. As well, carburetor adjustment will play an important part.

It is decidedly interesting to note the accompanying curve which shows the rapid drop in viscosity due to dilution. As can be seen, it does not require very much fuel mixed with the motor oil to reduce the viscosity or thin down the latter sufficiently to perhaps render it less effective, at least as a compression seal. It has also been determined that dilution occurs very rapidly over the first few hours of operation after the lubricant has been renewed in the crankcase.

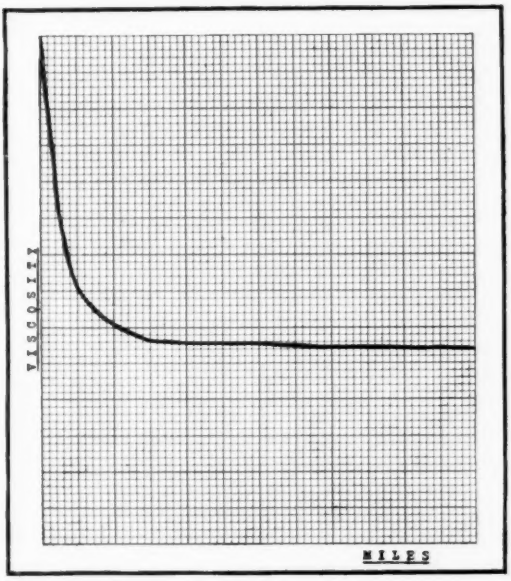


Fig. 1.—The above curve indicates how, in general, viscosity of motor oils decreases with mileage. Definite figures as to how rapidly viscosity reduction will take place (owing to dilution) or as to just what the ultimate viscosity will be, will vary in different instances. It has also been found that the curve will be relatively smooth in some cases while in others it will be undulated to a certain extent. The exact form of such a curve will depend upon the make of the car, its age, the efficiency of the engine, the amount of make-up oil added, and more particularly upon the ability of the driver to handle his car properly.

Withal the above, opinion differs as to the actual harmful effects that may result from crankcase dilution. **Certainly it alone is not the reason for changing our motor oils periodically.** In fact where dilution exists it is logical to expect that more power will be developed at the crankshaft due to the decrease in internal friction in the lubricant, provided it is not diluted to such an extent as to allow metal-to-metal contact. The presence of

water, sludge, emulsions, grit and dirt all tend quite as much to promote inefficient lubrication. In fact an excess of sludge which might clog oil ducts or render the pump inoperative would certainly cause more direct damage than a mere reduction in viscosity of the lubricant.

So much stress has been laid upon this matter of dilution by some authorities that a decidedly biased effect has been created. To be true, it *will* occur and that more rapidly in winter than in summer. This is a proven fact. It would appear that from a lubricating viewpoint there is little probability of bearings being actually burned out simply because the viscosity of the lubricant has been reduced. Any number of cases are on record where motor trucks have experienced dilution to the extent that their crankcase oil was decreased to less than one-fifth the original viscosity. Yet they operated effectively, and on examination their engine bearings showed practically no ill effects. Where trouble is experienced it will usually be due to abnormal operating conditions, as discussed hereafter.

Relation of Dilution to Pumping and Carbon Formation

One point must not be lost sight of, however, in considering this matter of dilution, *i.e.*, the relation it bears to excessive carbon formation, etc. Although it may be ultimately proven, as present conditions seem to indicate, that within reasonable limits dilution has no alarming effect upon the lubricating qualities of average motor and tractor oils, it certainly will have a tendency to increase carbon formation. It is perfectly evident that a lighter lubricant will splash more freely and increase the possibility of pumping or forcing of the lubricating film past the piston rings. A direct result of this occurrence will, of course, be carbonization due to the burning of the lubricant. This has no particularly bad effect if the lubricant burns cleanly. On the other hand, pumping will have little effect on operation when a straight distilled lubricating oil is used, except that consumption of the lubricant may be higher. As a rule far less carbon results from distilled oils than from residual products, and in general it is soft in appearance and easily removed.

Additional detrimental effects of pumping and dilution involve the possibility of a certain amount of loss of compression due to impaired piston seal when the lubricant becomes so low in viscosity as to lend itself to ready removal and transference to the cylinder head.

Equilibrium of Dilution

Just as surely as dilution will occur in practically every automobile truck or tractor engine, so surely will this dilution approach a point of equilibrium, although this will vary according to the design of the engine. In other words, experiments have proven that dilution of the lubricating oil with the heavier fractions of the fuel will go just so far, depending of course to some extent upon the nature of the constituents involved. Hence if an equilibrium condition in a certain make of car involved, let us say, 20% of diluent or fuel fractions, and this happened to be normal for a certain grade of lubricating oil, definite average temperature conditions, and a certain gasoline; were we to start with 40% of this diluent, the lubricating mixture in the crankcase would tend to return to its state of equilibrium after a sufficient length of time.

While the viscosity of the lubricating oil will tend to return to a certain normal after a sufficient period of time dependent on average operating conditions, in event of excessive dilution we must not rely on this phenomena to insure against faulty lubrication. Excessive use of the choke will often lead to abnormal dilution even to the extent of the fuel diluent becoming the major portion of the lubricating mixture in the crankcase. Thus, were the load to be applied suddenly, or the engine raced, the more volatile constituents in the lubricating mixture would tend to evaporate rapidly from the film on the upper part of the cylinder walls, due to their becoming rapidly heated. As a result the remaining quantity of lubricant might be so reduced as to be practically ineffective, and thereby lead to scored cylinder walls or even promote seizing in extreme instances of very abnormal dilution. It is important to remember that dilution both in its occurrence and in attaining its point of equilibrium requires an appreciable amount of time. Even after it does

become balanced, so to speak, it can be readily disturbed. Hence the prime controlling factor, the CHOKE, must be closely watched at all times, and never abused. We might get a little more apparent power on a winter morning were it used for five minutes when starting out, but does it pay to run the risk of damaging a good engine?

Precautionary Measures

In order to avoid as far as possible the objectional effects of crankcase dilution, and promote the efficiency of operation and life of the engine cylinders and bearings, certain precautions must be observed. These are briefly as follows:

a. Prime as little as possible.

b. When necessary to use the choke, let the sound of the engine be the guide. As soon as one or two revolutions are made and the engine indicates steady running, push the choke back in or turn the handle to "cold" position according to the make of the car.

c. Never flush the crankcase with kerosene alone except where arrangement of the oiling system permits complete drainage of the case. Always give it a final slushing with light motor oil. Kerosene is helpful in removing heavier particles of adhesive sludge.

d. See that the carburetor is properly adjusted to furnish the leanest mixture possible in conformation with atmospheric temperatures, and intensity of operation.

e. Whenever operating in cold weather, be sure that the hot air intake pipe attachment is in proper position to enable the admission of heated air to the carburetor.

Water

Water gains entry into the crankcase in several ways. A certain amount occurs due to condensation of steam, or water vapor, which is a by-product of combustion when the gaseous mixture of fuel and air is burned. This tends to blow by the pistons and enter the crankcase. Another prevalent source is the fuel tank; water being formed when moisture in the air contained in the tank is condensed. There are in addition certain other possible reasons for water accumulation via the fuel tank, such as were the filling cap not properly replaced, or in case certain of the top seams should leak. In event of the car being exposed to rain or snow, naturally some water could also be expected to find its way into the fuel.

However water may occur, the fuel system is in some way responsible. And water in the fuel means ultimately water in the lubricating oil and the possible occurrence of emulsions and sludge. Therefore it is to our best advantage to see that water does not gain entry into the system from external sources, or as a component part of our fuel. The other sources of water are relatively impossible of being controlled by the operator.

Water of condensation will be largely dependent upon weather conditions. During normal temperature operation any steam generated by fuel combustion will probably be emitted from the engine together with other waste or exhaust gases. In winter, however, especially when a cold engine is being warmed up or if the car has been out in the cold and is then driven into a heated garage, moisture will accumulate on the surface of the cold metal thus exposed to the warm air much as on a window pane. Also whenever the temperature of the jacket cooling water is low, a certain amount of steam will condense upon coming in contact with the colder parts of the cylinder head. Likewise condensation will occur in the air in the crankcase and fuel tanks.

The extent to which condensation will occur depends, of course, upon the prevailing temperatures. There will always be a tendency for such water of condensation in the combustion chamber to leak past the piston rings and find its way to the crankcase. During operation it will subsequently become agitated with the oil dependent upon the type of oiling system involved. Upon agitation or churning will depend the degree of ultimate emulsification.

While emulsions are the most prevalent results of water accumulation in the crankcase oiling system, we must never lose sight of the fact that in cold weather operation, even more serious consequences might occur due to freezing. Therefore water must be guarded against at all times. Under normal temperature operation emulsions become the chief objection. It has been proven repeatedly that even the purest grades of straight mineral oils will emulsify

when subjected to violent agitation in the presence of water, carbon and air. Though the extent of emulsification is naturally decreased by the selection of high grade motor oils, our problem is not of necessity entirely corrected.

During cold weather both free water and emulsions are subject to freezing, although the latter will have a somewhat lower freezing point. Actual formation of ice will often render the entire lubricating system inoperative in a force-feed or semi-splash installation, inasmuch as water will usually accumulate in a layer below the oil and surrounding the pump. In fact, if water accumulation is excessive and if the engine remains idle for any length of time without external heating and under atmospheric temperatures much below 32° F. (0°C.) the crankcase may become so cold as to permit this water to freeze and perhaps break the pump when the engine is started. Such a breakdown will impair circulation of oil throughout the system and as a result burned out bearings, scored cylinders, or seized pistons may occur.

Emulsions under similar conditions will freeze or at least become inert, although, as has been stated, at somewhat lower temperatures than water, depending upon the percentage of the latter involved. But freezing is not alone the objection in this case. At lower temperatures, even above the normal freezing point of water, emulsions will become so gummy as to practically introduce the same detrimental conditions as are met with when ice forms. To be true, a gum formation of this nature will not break the oil pump or screen, or damage the crankcase, but it will certainly reduce lubricating efficiency and ultimately bring about clogged oil ducts and piping, or cause the pump to stick. As a result frictional resistance will increase markedly, power consumption especially on warming up will be greater, and burned out bearings or scored cylinders, etc., will most surely be experienced if the car is run for any length of time without a complete overhaul of the lubricating system and renewal of the motor oil.

Solid Impurities

The function of lubricating oil in a motor car or tractor engine is two-fold, *i.e.*, it serves (1) to form a lubricating film between the rolling and sliding parts, thereby reducing frictional resistance to a minimum; and (2) as a seal between the cylinder walls and the piston rings, eliminating compression losses, provided it has sufficient viscosity.

The presence of solid matter of a gritty nature such as crystallized carbon or particles of road dust, would impair both the above functions which the lubricant must perform. It often happens that bearing troubles are experienced that can in no way be attributed to dilution or to the viscosity of the oil. Samples of the latter taken in certain instances, have even indicated no abnormal drop in viscosity. The appearance of the bearings in question, however, proved conclusively that scoring and wear had taken place due to the scraping action of some harder substance than the bearing metal.

Dirt, grit and other abrasive particles may find their way into the lubricating system in a number of ways. The oil may originally have contained such foreign matter if it had not been carefully refined; the oil storage or measuring containers may have been dirty; the operator may have neglected to replace the cap on the filling pipe, or have accidently brushed some dirt from the hood or engine into this pipe or his filling measure; or road dust, etc., may have been taken into the engine with the air, either by way of the carburetor or the crankcase breather device.

Just as long as the lubricating film is sufficiently thick to prevent any such foreign matter from coming simultaneously into actual contact with both bearing surfaces, little or no damage will result, and the possibility of scoring will be negligible. But as soon as the viscosity of the lubricant becomes so lowered by dilution that the film thickness is materially decreased, it will no longer serve as a carrying medium for abrasive foreign matter. In other words, such particles of grit, dust or dirt as may gain entry to the bearings will be carried through them in actual contact between the wearing surfaces, and scoring will be bound to occur.

Number	1	2	3	4	5*	6
Water	2.0%	Trace	14.3%	Trace	98.0%	.....
Carbonaceous Matter	50.0%	93.8%	14.3%	83.4%	0.9%	86.8%
Metal Particles and Road Dust	48.0%	6.2%	71.4%	16.6%	1.1%	13.2%

*In this test note that the ratio of metallic particles and road dust to carbonaceous matter is comparatively high.

ANALYSES OF CRANKCASE SLUDGES

These figures have been computed, deducting the amount of free oil that is usually entrained in the sludge.

Note the wide variations that may occur. The percent of abrasive matter present, such as carbon, metallic particles and road dust, can be attributed largely to the nature of operation and the type of highways traveled. Metallic particles are chiefly due to worn or scored bearing surfaces, or cylinder walls.

It is therefore evident that a definite relation exists between dilution and bearing breakdowns. A low viscosity alone will practically never be responsible for such difficulties in the average gas engine. There are instances on record of motor trucks which are operating continually and efficiently today under unusually severe conditions of dilution. Yet their bearings show no ill effects either from scoring, or overheating. This would indicate that in some instances a viscosity of 100 seconds Saybolt, or even less is not too low to insure an effective film of lubricant wherever necessary; and just as long as actual solid or semi-solid impurities are removed (by draining the crankcase) so frequently as to prevent excessive accumulation, no material damage will result. **Actual dilution alone, therefore, is not deleterious, but dilution in company with impurities which will clog the oiling system or break down the lubricating film is a most serious problem.**

In an effort to reduce the possibility of bearing troubles many motorists are prone to select a motor oil of higher viscosity than ordinarily necessary, in the belief that thereby will they counteract the effects of dilution. This is a mistaken idea inasmuch as the more viscous the oil the greater will be the rate of change of viscosity. In other words, when there is a high percentage of fuel diluent present, the ultimate viscosities of practically all oils (in their state of dilution equilibrium) will be very nearly the same indicating that the higher the original viscosity the more rapidly will it decrease in proportion with the entry of fuel diluent. In addition, where higher viscosity lubricants are used, there will be a greater fluctuation in ultimate viscosity during daily operation on account of varying heat conditions of the engine, intensity of operation and atmospheric temperatures.

Thus the average thickness of the lubricating film will be but slightly affected, in event of using a heavier lubricant originally. As well, until the equilibrium point of dilution has been reached there would be the possibility of excess power being necessary to overcome fluid friction. Especially if there is any sludge or other residual foreign matter remaining in the crankcase will there be possibility of this being carried to certain of the bearings, or even clogging the oil ducts. Accumulation of this nature will more readily mix with a heavy lubricant when the crankcase is filled, and will tend to remain in suspension due to the viscosity of such an oil preventing complete precipitation.

Far better would it be to fill the crankcase after each draining with oil of the proper viscosity, and use a somewhat heavier product as make-up lubricant. Thereby could we reduce normal operating dilution to a certain extent. Owing to dilution and operating temperatures, the old idea that we can increase viscosity and thereby make the oil take the place of worn metal to a certain extent, must evidently be discarded. **The only way to cure worn bearings or loss of compression due to worn piston rings or cylinders, is to replace them mechanically. The use of a heavier lubricant is but a very temporary and ineffectual makeshift at best.**

Carbon Formation

A certain amount of free carbon will be present in practically every crankcase after the lubricant has been in service a short time. In part this is caused by breaking down or partial decomposition of the lubricating oil; and in part to incomplete combustion of the fuel. Subsequently certain of the resultant carbon of fluffy or pulverized nature is carried into the crankcase by the diluent portions of the fuel, or the lubricating film on the cylinder walls.

Carbon is detrimental in that it not only promotes the formation of crankcase sludge, but as well is influential in producing emulsions.

Draining the Crankcase

In order to minimize the effects of contamination of motor oils the crankcase must be regularly drained. The frequency of draining will, of course, depend to some extent upon the operating conditions to which the car is subjected, the grade of fuel, and the season of the year. In general it is advisable to change the oil after approximately every 500 miles of operation, or at weekly intervals if intermittent driving is customary with a considerable number of starts and stops.

Crankcase draining should be carried out just after a run and while the engine is still hot. A considerable percentage of the contained solid impurities and sludge will thus have become churned up in the oil and can so be readily removed with the oil, obviating the necessity of flushing the case to any great extent. One or possibly two flushings with about a quart of warm light motor oil, however, will never be amiss and is always an insurance that dirt and sludge have been removed from certain corners and crevices in the engine when the oil does not circulate freely. Kerosene alone as an engine wash is not recommended due to the possibility of a certain amount of it remaining in parts of the case which are set at a lower level than the drain plug, and thus being the subsequent cause of a certain amount of dilution. When the engine is flushed it should be turned over slowly either by hand or with the starter. It is bad practice to run it under its own power, inasmuch as there will be danger of lack of lubrication and therefore damage to the bearings.

Where the car is new and the engine must be broken in, or where the cylinders have been recently re-bored, a certain amount of the metallic bearing surfaces will have a tendency to wear down or become polished. The result of this is the formation of minute particles of metal which will constitute part of the sludge. Usually this will take place until bearing and cylinder walls have been worked down to a "running fit". Such a fit will be attained after approximately 1,000 miles of service. Therefore it is advisable to change the motor oil more frequently over this period of operation. If the crankcase is drained and flushed in the usual manner after each 200 to 300 miles of operation, four of such changes should suffice to remove excessive abrasive and metallic material and insure against the occurrence of any abnormal wear of bearings, piston rings, or cylinder walls, etc., or the possibility of clogged oil ducts or pump screen.

Conclusion

Therefore, on account of the presence of fuel diluent, water, dirt, sludge and carbon, the oil should be drained regularly from the crankcase and fresh oil substituted. **The presence of contaminating foreign matter demands this procedure, rather than any decrease in the potential lubricating value of the oil.** The latter still retains this characteristic, and is only prevented from effectively performing its intended function by the excess of foreign matter which has accumulated.

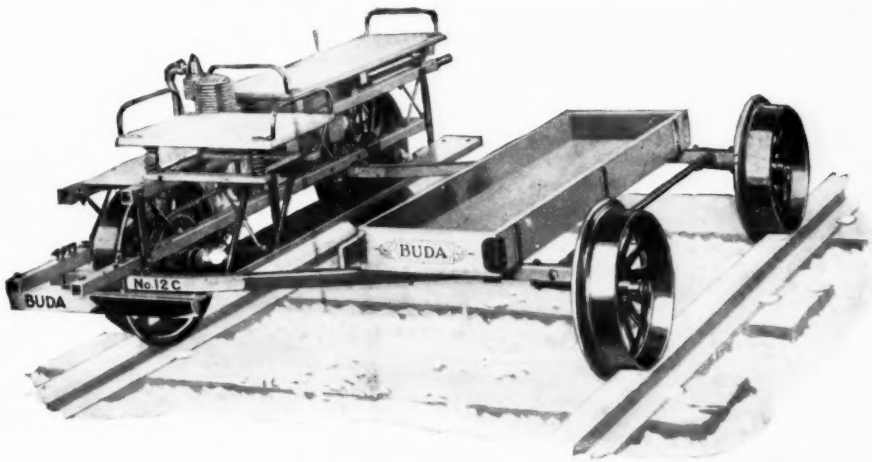
Hence, drain your crankcase after approximately every 500 miles of operation, or more frequently if you deem it necessary, and you will insure your peace of mind, comfort, and the life of your car.

Lubrication of Railway Motor Cars

RAILWAY motor cars came into existence about 25 years ago when an enterprising section foreman one day discovered he could mount a gasoline engine on his old hand car and save himself and his gang the hard back-breaking work of propelling the car over the section. Soon too, he found out he was saving considerable time for the company by getting his men to and from their work more rapidly, and by putting them on the job in much better spirits both physically and mentally.

Since that humble beginning so valuable have become the time and labor that can be saved

by using the gasoline propelled section car in preference to the old fashioned hand car, that the former is being adopted today to a greater extent than ever before. With this evolution naturally the care and upkeep of such cars became a problem. Many of the larger railroads, therefore, organized a regular department or force for this purpose. Others, not having the equipment or men available, simply made provision for the overhauling of their cars at periodic intervals, and the carrying of sufficient stock for their maintenance.



Courtesy of The Buda Company

Fig. 2.—Type of railway motor car used for inspection and maintenance of way service.

Track motor car engines are forced to work under very unfavorable conditions most of the time, such as being heavily overloaded, run at high rates of speed and sometimes handled by an inexperienced operator. In general operation nothing plays a more important part toward keeping the maintenance of track motor cars at a minimum than proper lubrication. As one manufacturer put it, "Successful operation of track motor cars is largely a problem of lubrication and adjustment". However, before the correct lubricants can be selected it is necessary to know the type of machine you are dealing with and what system is employed for lubricating it.

Types of Engines

Track motor car engines are of the internal combustion type, either two or four cycle, and use kerosene or gasoline for fuel. They are built with one, two, three or four cylinders. The two stroke cycle, single cylinder air-cooled engine predominates in the lighter class of cars, but for heavier work the multiple cylinder engine of either two or four cycle, and air or water-cooled, will be found in great numbers. In the four cycle type of engine the cycle of events, *i.e.*, intake, compression, explosion and exhaust, are completed in four strokes of the piston. In other words, the explosion in the four cycle engine comes on every fourth stroke of the piston, while in the two cycle engine it comes on every second stroke. Because of this fact the two cycle engine can be made to develop more power per unit of weight than the four cycle engine, which in some instances is an advantage. However, there are advantages and disadvantages to be found in both types of engines. With the explosion occurring on every second stroke the two cycle engine will develop considerable more heat than the four cycle engine, and for this reason it is more difficult to lubricate.

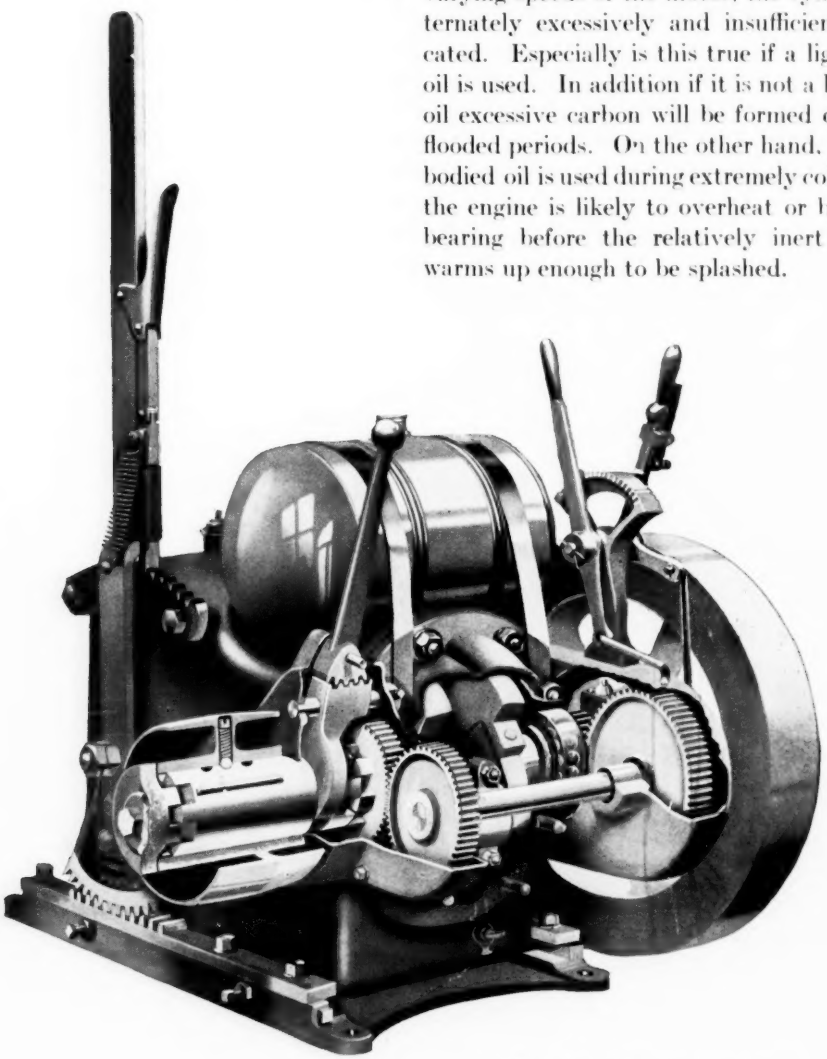
With the majority of track motor car engines of the two cycle air-cooled type, we have a condition that is just the reverse of what is found generally in the common automobile engine. In the latter there is a water-cooled, four cycle engine with a very efficient system for its lubrication. Either a full force-feed or a combination of the force-feed and splash system is employed. Thus when this type of engine is running properly, the lubricating oil will not be subjected to

anything like the high temperatures found in the two cycle, air-cooled engine. Because of this condition and the many types of track motor car engines on the market, no one grade of oil will successfully lubricate them all.

Lubricating Systems

As well as the different types of engines, we have the various systems of lubrication to contend with, which adds to the difficulty of lubricating with one oil throughout the entire year. With the force-feed and splash system a pump is generally located in the base of the oil reservoir which forces the oil through pipes and drilled passages to the parts to be lubricated. Where the lubricant is not fed directly to the cylinder walls and pistons, the oil spray and drippings thrown from the moving parts are sufficient to lubricate them.

The true splash system depends entirely upon the ends of the connecting rods dipping into the oil and splashing it out to the cylinder walls and other bearing surfaces. Owing to the irregular supply of oil with the splash system, due to varying speeds of the motor, the cylinder is alternately excessively and insufficiently lubricated. Especially is this true if a light bodied oil is used. In addition if it is not a high grade oil excessive carbon will be formed during the flooded periods. On the other hand, if a heavy bodied oil is used during extremely cold weather the engine is likely to overheat or burn out a bearing before the relatively inert lubricant warms up enough to be splashed.



Courtesy of Northwestern Motor Company

Fig. 3.—Detailed illustration of a two-speed, ball bearing railway motor car engine. This is a two-cycle type, free running, water cooled reversible machine, equipped for positive lubrication. Note reduction gears for speed transmission.

In those cars where the oil is carried in the crankcase it is very necessary and essential that the crankcase be drained and cleaned from time to time, as is the practice with automobile engines. If this is not done the oil will in a very short time become very thin from dilution by the fuel that works past the piston rings into the oil reservoir. There will also always be a certain amount of dust and dirt present which will find its way into the crankcase (besides the free carbon) which will tend to clog up the pump and pipe connections.

Some lubrication systems are very effective in the distribution of light and medium bodied oils. This applies to the splash system. On the other hand, the force-feed system will not only function satisfactorily with the light and medium bodied oils but will handle the heavy and extra heavy grades if judgment and care are exercised in the selection and location of the pump with reference to oil passages and weather exposure.

The majority of track motor car engines, however, are lubricated by mixing the lubricating oil with the fuel. The amount of oil to be used will depend on whether the engine is air or water cooled and the nature of the work it is called upon to perform. With the same class of work the air cooled engine will require a richer mixture of oil and fuel than a water cooled engine. The oil and fuel should at all times be accurately measured and thoroughly mixed before being put into the fuel tank. Mixing may be accelerated in cold weather by slightly heating the lubricating oil before adding it to the fuel. If this is not done and the oil is poured into the tank without mixing, it will settle to the bottom of the tank with a tendency to clog the fuel line and give considerable carburetor trouble, and eventually no lubrication at all. Where the oil and fuel are mixed, a high grade lubricant should always be used, and it should be suited in every way to the engine. It will necessarily require more of a poor grade oil to properly lubricate a gas engine than of an oil especially designed for gas engine lubrication; and should the mixture become too heavy to vaporize properly in the carburetor, there will be slow burning in the combustion chamber, with the formation of considerable carbon. With the formation of excessive carbon the ports will become restricted, the deflector filled up, rings stuck and there will be a general falling off in efficiency of the entire engine. There will always be some carbon formed, even with the best oils; but the better the oil used the longer the engine will continue to run well and keep clean.

One of the ever present trouble makers in the internal combustion engine is carbon. Where the manufacturers have not made provisions to keep excess oil from reaching the combustion chamber, the oil recommended should be of such a character that it will burn cleanly, with minimum carbon formation. If carbon formation is of a hard, crystalline nature its presence will be manifested in the overheating of the engine, with a decided loss of power and a generally poor running machine. The troubles traceable directly or indirectly to the formation of carbon in the internal combustion engine are too numerous to discuss in this article.

In addition to the formation of carbon when using poor lubricating oil, we do not get as effective a piston seal between the piston rings and cylinder with a poor oil as with one designed especially for the type of engines in track motor cars. Unless this seal is maintained the engine will not develop the proper compression for the most powerful explosion. Also, if this seal is not maintained, the compression and explosion pressures of the four cycle engine will cause the heavier unvaporized parts of the fuel to leak past the piston rings into the crankcase, thus diluting the lubricating oil considerably and necessitating more frequent draining of the crankcase.

Grades of Lubricants

By means of tests extending over several years, both at the shop and out on the road, the best oil for two cycle, air-cooled and water-cooled engines, where the lubricating oil and fuel are mixed, has proved to be of about the following specifications:

Flash	Above 375° F.
Fire	450-500° F.
Viscosity at 100° F.	1000-1500″ Saybolt

An oil meeting, approximately, the above specifications may be used the entire year in such engines, provided care and judgment are exercised in mixing the proper proportions of oil with the fuel. Ordinarily one quart of lubricating oil to five gallons of fuel will give very satisfactory lubrication. There will be occasions, however, when this proportion will have to be decreased or increased, depending on the nature of work the engine is called upon to perform, and the atmospheric temperature.

For engines employing the splash or force-feed system, or a combination of these, best results are obtained by using two grades of oil, one for summer and one for winter. From a lubrication standpoint the most trouble is experienced with cars of this type: for where one oil will work satisfactorily in summer it will give considerable trouble in extremely cold weather. Oils are produced, however, which may be used in the above type of cars the year round if the proper care and attention are given to the starting of the engine on cold days. By this is meant allowing the engine to run without load or to idle for several minutes, until it warms up sufficiently to thin the oil to a state where it will be easily splashed or handled by the pump.

Where one oil is used as above for this class of engines it should be of approximately the following specifications:

Flash	Above 375° F.
Fire	450-500° F.
Viscosity @ 100° F.	350-450″ Saybolt

Where two grades of oil are used, one for summer and one for winter, they should approximate specifications as follows:

	Summer Grade	*Winter Grade*
Flash	350-400° F.	325-375° F.
Fire	450-475° F.	425-450° F.
Viscosity 100° F.	750″ Saybolt	300-500″ Saybolt
Pour Test	0° F.	0° F.

Miscellaneous Lubrication

The lubrication of other parts of the car should not be difficult. Where there are grease cups on the crankcase bearings, loose wheels and axle boxes, a good grade of motor cup grease which will not melt out too easily, should be used. The frequency with which grease cups should be screwed down depends on the class of service the car performs. For general lubrication where oil is employed using cup or hand oiling the lubricant that is used for the engine will answer all purposes.

The transmission system varies with the make and type of car; and drive may be accomplished through different arrangements such as direct connection, direct connection through gears, direct connection through gears and chain, free running clutch and gears, free running belt, friction wheel and disc, chain and friction wheel and disc, chain and clutch, etc., etc. The lubrication of the transmission mechanism will depend entirely on the arrangement employed and the type of car.

Gearing should generally be lubricated with a good grade of straight petroleum gear compound having a viscosity of about 200″ Saybolt at 210° F. Under all conditions this lubricant should be capable of affording a sufficient film of lubricant between the gear teeth, though it should never be so heavy as to cause an excessive consumption of power. On such bearings as are installed the grade of oil used on the main engine will generally be suitable. Friction wheels require no lubrication of the frictional surfaces, and generally the lubrication in such a system will be confined solely to bearings.

Conclusion

To maintain the track motor car at its highest degree of efficiency it is evident that great care must be given to the selection of the proper grade of lubricant for each purpose. Motor cars represent a very valuable investment, and trying to lubricate them with a poor oil or one not suited for the purpose intended will only hasten the deterioration of the wearing surfaces to the point where the car will have to be called in from service to be generally overhauled.

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